

## **Appendix O**

### **Delfin LNG Construction Vessel Anchoring Plan**

Addendum, Provided April 6, 2016



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Port Delfin LNG Project

**Construction Vessel Anchoring Plan**  
(Draft)

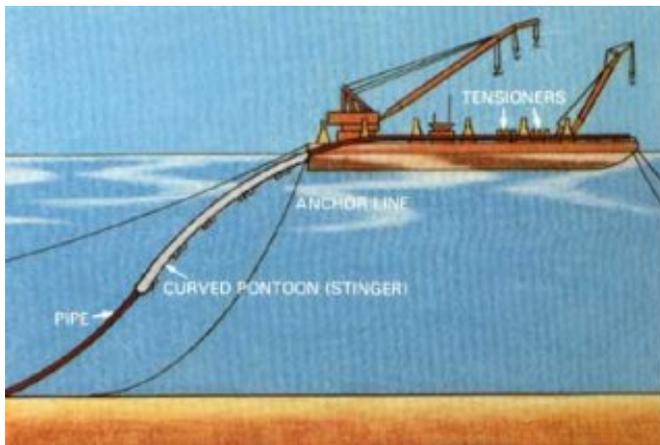
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## Delfin LNG Construction Vessel Anchoring Plan

### 1.0 Background

The specific vessels, anchor sizes, and techniques to be used in installing the Delfin LNG pipelines and Tower Yoke Mooring Systems (TYMSs) structures will be determined during detailed engineering of the Delfin LNG project and upon selection of individual contractors and equipment. The discussion below represents Delfin LNG's Construction Vessel Anchoring Plan (draft) as currently envisioned and includes the expected equipment and installation techniques to be used in developing the project.

1.1 The traditional method for installing offshore pipelines in relatively shallow water is commonly referred to as the S-Lay method because the profile of the pipe as it moves in a horizontal plane from the welding and inspection stations on the lay barge across the stern of the lay barge with a curved "stinger" and then onto the ocean floor forms an elongated "S." See figure 1 below.



**Figure 1: S-Lay barge (illustration from [www.globalsecurity.com](http://www.globalsecurity.com))**

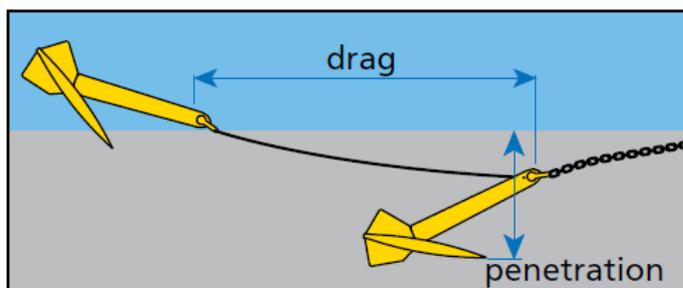
1.2 In shallow water (less than 200 feet deep for purposes of this discussion) the lay barge is typically moored by anchor lines as dynamically positioned pipe lay vessels are less efficient and rarely used at these relatively shallow depths (MMS, 2001). When laying down the pipe on the seabed the lay barge will need to move continuously forward as the pipe is laid down on the seabed from the vessel's stern. To accomplish this, the anchor lines at the bow will be pulled in while the anchor lines at the stern will be gradually let out. For pipe lay vessels, additional anchors are positioned offset on each side from the direction of travel to achieve lateral station keeping. Anchor lines running to these lateral positioning anchors must likewise be adjusted in or out to maintain station on the centerline of the pipeline being installed.

1.3 There is a maximum length of mooring line available onboard the lay barge and therefore, the anchors will need to be moved up and reset periodically as the lay barge moves forward laying pipe. The number of times a lay barge will need to reset anchors is dependent on the length of pipeline to be laid down and the length of the anchor cables on the lay barge.

1.4 The typical mooring configuration of a moored S-lay barge is an 8-Point mooring line system with high holding power anchors, like Delta Flipper, Stevin, Stevpris, Bruce and similar. The most typical anchor size and weight for a Gulf of Mexico lay barge is probably the Delta Flipper 6.8 ton anchor. However, there are lay barges with anchors up to and exceeding 15 tons depending on the size of the lay barge and the barge operator's preference. Larger anchors are typically used with increasing water depth and bigger pipe lay barges.

1.5 In addition to the lay/trench barge for the pipe laying operation there will be a derrick crane barge for the installation of the Tower Yoke Mooring System (TYMS). For the water depth and site location of the Delphin LNG Project and for the purpose of this plan, typical anchor sizes of 10 tons are assumed to be used on both the lay/trench barge and the derrick crane barge. For many of the Delfin LNG installation operations there will also be a typical 4-point moored Dive Support Vessel (DSV) involved. The anchors for these vessels are smaller and for the DSV a 5 ton anchor has been assumed.

1.6 The drag distance and penetration depth of the anchor when pulled in is dependent on the pull in load, the anchor type and the soil conditions. For definition of drag distance and penetration depth see figure 2 below.



**Figure 2: Illustration of anchor drag and penetration depth (from [www.vryhof.com](http://www.vryhof.com))**

1.7 Anchor manufacturers have developed performance charts for various anchor types as a tool for estimating anchor drag distance and penetration depth during the anchor setting process. The anchor performance characteristics of the Vryhof Stevin Mk3 have been used for the purpose of this evaluation/plan. The Vryhof Stevin Mk3 is a common anchor that has been around for several decades. This anchor type is representative for the applications being considered and Vryhof makes the anchor performance charts available on the internet. To estimate the anchor drag distance and penetration depth for anchoring the vessels involved in the construction of the Delfin LNG Project the following applies:

- The Anchor Drag and Penetration Chart for the Vryhof Stevin Mk3 (Figure 3) is used as the reference anchor.
- Medium clay at the Delfin LNG site is used based on observed conditions.
- The anchor size of the pipe lay barge and derrick barge is assumed to be 10 tons.
- The anchor size of the DSV is assumed to be 5 tons.

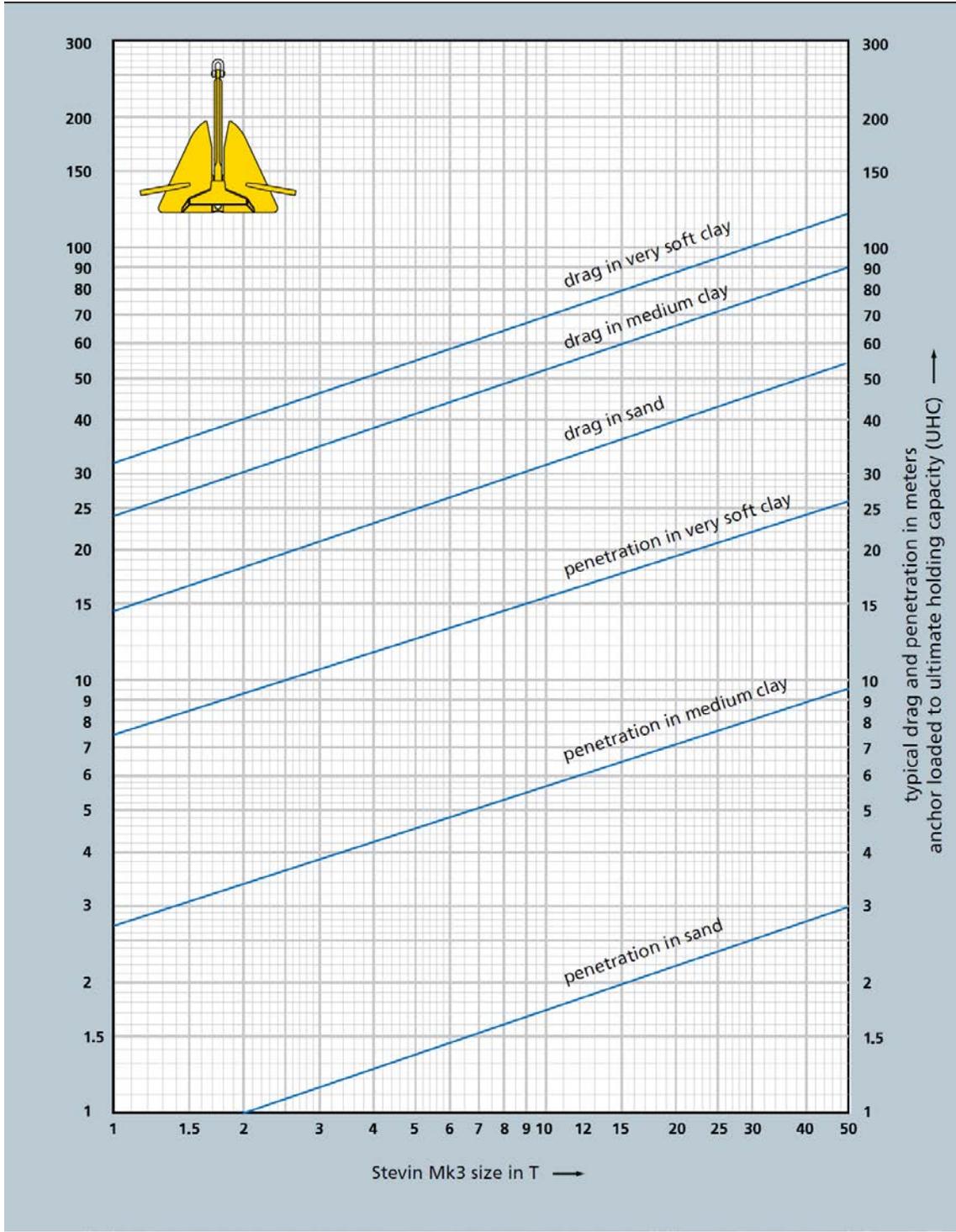


Figure 3 - The Stevin Mk3 Anchor Drag and Penetration Chart (from [www.vryhof.com](http://www.vryhof.com))

1.8 Note that drag distance and penetration depth given in the chart is for the anchor loaded to the Ultimate Holding Capacity (UHC). This is a conservative number as the operator will likely not pull the anchor to the UHC load every time it is set. As such, the actual anchor drag distances and penetration depths shown in the charts likely overestimate what will be observed in practice.

## 2.0 Construction Vessel Anchoring Plan

2.1 The Delphin LNG Project would have three principal locations for use of the lay/trenching barge and construction derrick barge for the installation of:

1. WC 167 Platform 700 feet pipeline bypass installation (42-inch diameter).
2. A total of four 6,400 feet long, 30-inch diameter pipeline laterals extending from the existing HIOS pipeline to each of the FLNGV Tower Yoke Mooring Systems (TYMS).
3. A total of four TYMS.
4. The DSV will be involved in the pre-commissioning of the system.

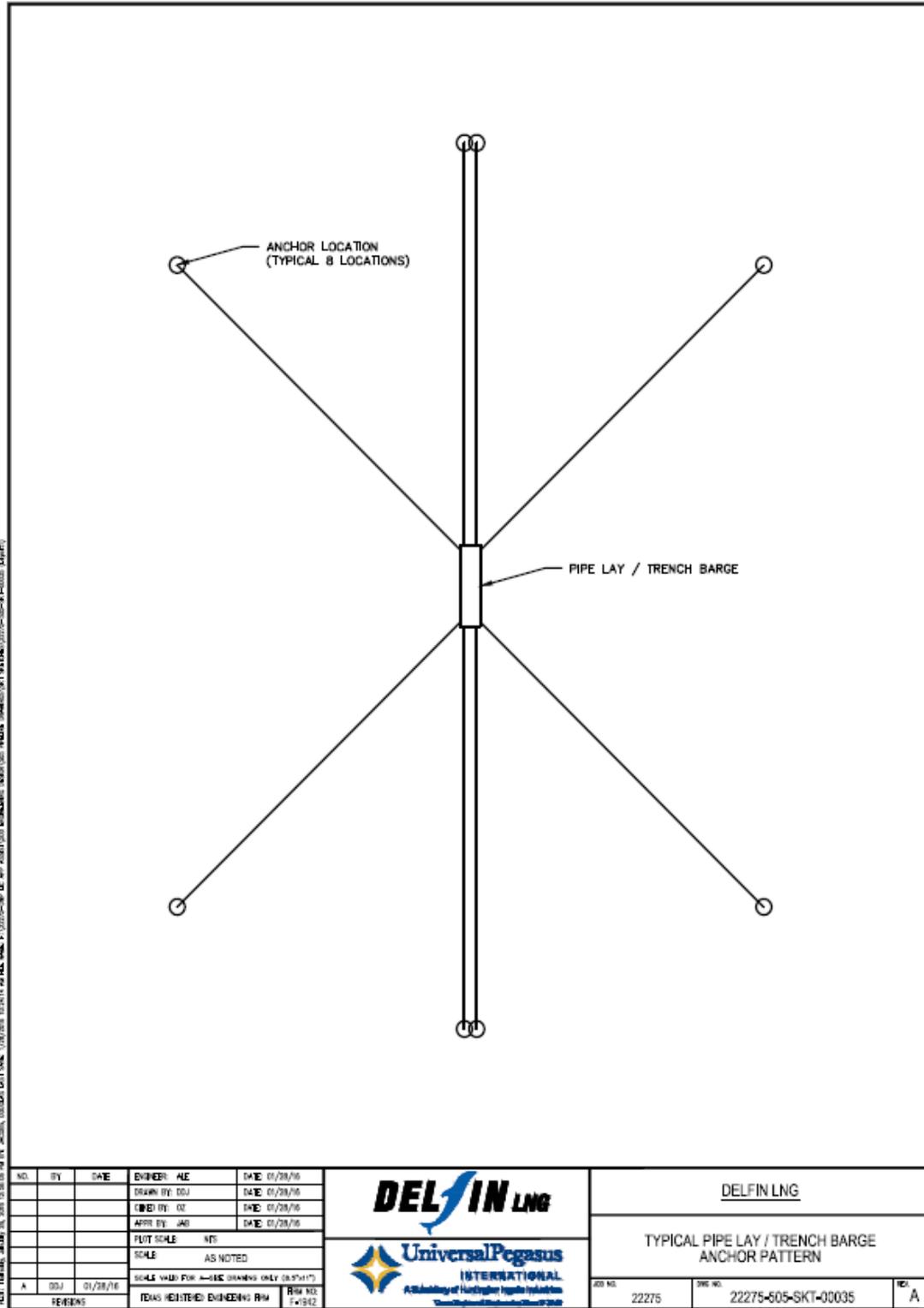
2.2 Using the Stevin Mk3 Anchor Drag and Penetration Chart in Figure 3, the following Table can be developed to describe the likely vessel anchoring associated with construction of the Delfin LNG project:

<b>Moored Vessel Operations and Anchor Activity</b>	Vessel	Total Days Moored	No of times setting Anchors	No of Anchors on Vessel	Max Anchor drag (m)	Max Anchor depth (m)	Comments
<b>WC 167 Bypass pipeline</b>							All work by DSV
Install and trench 700' bypass pipeline	DSV	70	2	4	40.0	4.5	
<b>Install 4 pipeline laterals</b>							All 4 laterals installed first year
Pipelay of 4 laterals	Lay/ Trench Barge	14	12	8	55.0	6.0	
Flood & hydrotest of 4 laterals	DSV	12	8	4	40.0	4.5	
Trenching of 4 laterals	Lay/ Trench Barge	13	12	8	55.0	6.0	

<b>Moored Vessel Operations and Anchor Activity</b>	Vessel	Total Days Moored	No of times setting Anchors	No of Anchors on Vessel	Max Anchor drag (m)	Max Anchor depth (m)	Comments
<b>Connect 4 pipeline laterals to Main Line</b>							All 4 laterals installed first year
Install 4 hot tap tees and perform hot taps	DSV	62	8	4	40.0	4.5	
Install 4 spool connections to main line	DSV	16	4	4	40.0	4.5	
<b>Pre-commissioning</b>							
Pre-commission the System	DSV	49	2	4	40.0	4.5	
<b>TYMS Installation</b>							
							One TYMS first year. TYMS added as expansion progress Fully developed (x 4)
Installation of TYMS	Derrick Barge	43 (172)	1 (4)	8	55.0	6.0	
Installation of tie-in spool connections to TYMS	DSV	3 (12)	1 (4)	4	40.0	4.5	

**Table 1 – Moored Vessel Operation and Anchor Activity Table**

Typical mooring arrangements for a pipe lay/trench barge and a dive support vessel are shown in Figures 4 and 5 below:



NO.	BY	DATE	ENGINEER	AE	DATE	01/28/16
			DRAWN BY	DDJ	DATE	01/28/16
			CHECKED BY	OZ	DATE	01/28/16
			APPROVED BY	JAO	DATE	01/28/16
			PLUT SCALE	NFS		
			SCALE	AS NOTED		
			SCALE VALID FOR	—(SEE DRAWING ONLY (8.5x11"))		
A	DDJ	01/28/16	TEXAS REGISTERED ENGINEERING FIRM	REG. NO.	141942	
					DELFIN LNG	
						
					JOB NO.	22275
					DWG. NO.	22275-605-SKT-00035
					REV.	A

Figure 4: Typical Pipe Lay / Trench Barge Anchor Pattern

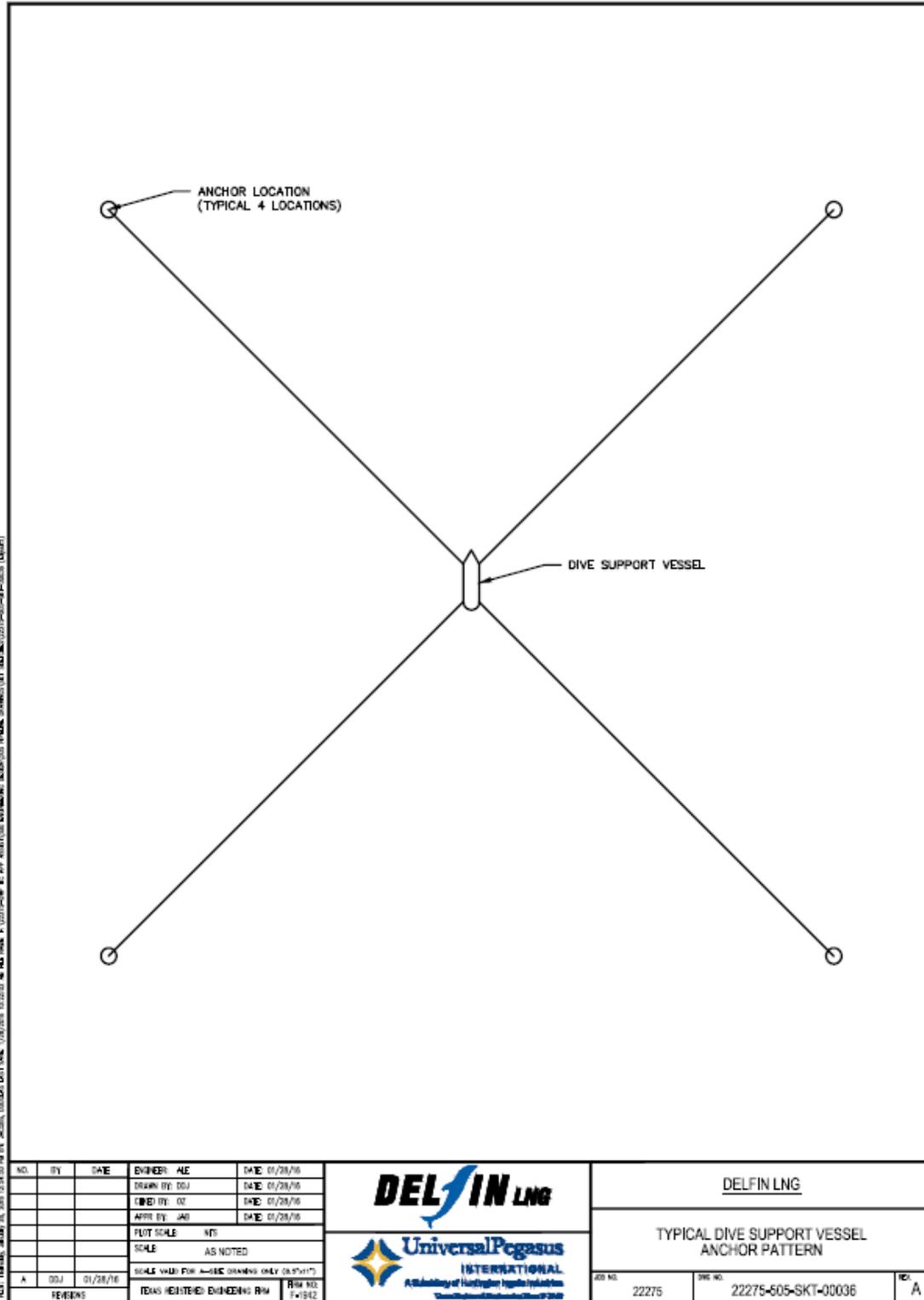


Figure 5: Typical Dive Support Vessel Anchor Pattern

### **3.0 Anchor Use Environmental Impacts and Mitigation.**

3.1 The primary mitigation used by offshore project developers to avoid and minimize potential environmental impacts from the use of anchors during offshore construction activities is the use of high resolution geophysical and archeological surveys capable of identifying areas of coral reefs, hard bottom, and other sensitive benthic habitat along with evidence of shipwrecks or other cultural resources. Delfin LNG performed these investigations and they have been submitted in Volume III of Delfin's Deepwater Port license application at Attachments 2, 3, 4, 5, and 6.

3.2 These investigations were performed by Fugro Geoservices, Inc. in compliance with the applicable Bureau of Ocean Energy Management (BOEM), and Bureau of Safety and Environmental Enforcement (BSEE) Notice to Lessees concerning geophysical, archeological, and benthic habitat evaluations. Neither coral reefs nor sensitive hard bottom habitat were noted within the surveyed areas. The geophysical and archeological investigations did; however, detect a number of sonar contacts and magnetic anomalies several of which were recommended for avoidance/offsets from bottom disturbing activities to avoid damaging potential cultural resources. Delfin proposes to comply with these recommended offsets to avoid potential harm to cultural resources.

**Delfin Mitigation: Comply with the avoidance and offset zones for the designated sonar and magnetic anomaly contacts recommended in the Fugro Geoservices, Inc. reports.**

3.3 *Environmental Impacts from Anchors.* Anchor placement and removal can result in localized short-term impacts to benthic habitat and substrate. In a uniform substrate composed of sand, silt, and clay such as that occurring along the proposed Delfin LNG project pipelines and TYMS, the anchors can crush or displace organisms living on or within the sediments when they are placed on the bottom and subsequently "set" in location by being pulled into the bottom. The potential depth of penetration and drag across the sediments was discussed above and presented in Figure 3, the Stevin Mk3 Anchor Drag and Penetration Chart. In addition to penetrating the sediments and potentially dragging a short distance during the setting process, anchors will also disturb the sediments upon removal as they are forcibly pulled from the bottom causing the sediments to be disturbed in the local area. Depending upon the physical composition and nature of the sediments, the anchor setting and removal process can result in a localized scar or depression of several inches or potentially several feet in depth where the anchor was dragged, set and subsequently removed. These localized anchor scars can persist for several days, weeks, or months depending upon the physical characteristics of the local sediments. Benthic habitat recolonization of the disturbed sediments will begin to occur during the period of anchor placement (depending on duration) and immediately following removal. Over time, remaining anchor scars will be filled in by the surrounding sediments and subsequent sedimentation and will make the anchor site indistinguishable from the surrounding substrate.

3.4 *Environmental Impacts from Anchors Chains and Cables.* In a uniform substrate composed of sand, silt, and clay, anchor chains and cables can also result in localized disturbance of the topmost portion of the benthic habitat as the chain and cable can swing across the top of the sediments and periodically touch bottom in some cases. These episodes of anchor chain and cable contact with the sediments can result in localized displacement of crabs, shrimp, and other crustaceans and similar organisms that inhabit the seafloor and shallow burrowing benthic organisms. These impacts would generally be short term and localized in nature with conditions quickly returning to baseline following removal of the anchor, chain, and cables.

3.5 *Environmental Impacts from Anchors and Pipeline Installation on Water Quality.* The Bureau of Ocean Energy Management (formerly the Minerals Management Service -MMS), has evaluated the potential impacts to water quality as a result of the placement of anchors and the installation of pipelines. In a 2001 overview of the potential impacts of installing oil and gas pipelines on the Gulf of Mexico Outer Continental Shelf, MMS noted the following potential impacts to water quality:

*There are two potential sources of impact on ambient water quality from pipeline installation operations: disturbance of seafloor sediments and discharges from installation vessels. Setting anchors and installing the pipeline are expected to cause local disturbance of the seafloor, which will cause sediments to become suspended in the near-bottom water column. This alteration of water quality is expected to be localized and temporary, ceasing when installation activities are complete. Pipeline installation activities do not involve discharges into the water, other than the normal release of those associated with accommodation for workers on board each vessel. These discharges include domestic wastes (for example, sanitary wastes and gray water), bilge water, and food scraps. The nature of these discharges will conform to regulatory requirements appropriate to each vessel. (MMS, 2001)*

## **References**

U.S. Mineral Management Service. 2001. Brief Overview of Gulf of Mexico OCS Oil and Gas Pipelines: Installation, Potential Impacts, and Mitigation Measures. OCS Report MMS 2001-067.

## **Appendix O Addendum**

**Provided April 6, 2016**

DEFLIN LNG PROJECT – RESPONSE USCG DATA GAP No. 144

TABLE 1

Vessel Anchor Activity	Vessel	No. of Times Setting Anchors	No. of Anchors on Vessel	No. of Sets per Anchor	Max Anchor Drag (ft)	Max Anchor Drag Width (ft)	Area of Potential Impact from Anchor Drag (acres)	Max Anchor Line Laying on Sea Floor (ft)	Max Anchor Line Sweeping Width (ft)	Area of Potential Impact from Anchor Line Sweeping (acres)	Total Area of Potential Impact (acres) per Anchor per Set	Total Area of Potential Impact (acres)	Substrate Type Potentially Impacted
<b>WC 167 Bypass Pipeline – All work done by DSV</b>													
Install and Trench 700 ft bypass pipeline	DSV	2	4	2	131.2	10	0.03	1,250	100	1.43	1.46	11.68	Uniform fine sandy, silty clay
<b>Install 4 Laterals – All 4 laterals installed first year</b>													
Pipelay of 4 laterals	Lay/Trench Barge	12	8	3	180.4	10	0.04	1,250 <sup>A</sup> /1,000 <sup>B</sup>	100 <sup>A</sup> /1,000 <sup>B</sup>	1.43 <sup>A</sup> /9.94 <sup>B</sup>	1.47 <sup>A</sup> /9.98 <sup>B</sup>	17.64 <sup>A</sup> /119.76 <sup>B</sup>	Uniform fine sandy, silty clay
Flood and Hydrotest of 4 Laterals	DSV	8	4	2	131.2	10	0.03	1,250	100	1.43	1.46	11.68	Uniform fine sandy, silty clay
Trenching of 4 Laterals	Lay/Trench Barge	12	8	3	180.4	10	0.04	1,250 <sup>A</sup> /1,000 <sup>B</sup>	100 <sup>A</sup> /1,000 <sup>B</sup>	1.43 <sup>A</sup> /9.94 <sup>B</sup>	1.47 <sup>A</sup> /9.98 <sup>B</sup>	17.64 <sup>A</sup> /119.76 <sup>B</sup>	Uniform fine sandy, silty clay
<b>Connect 4 Pipeline Laterals to Main Line - All 4 laterals installed first year</b>													
Install 4 Hot Tap Tees and Perform Hot Taps	DSV	8	4	2	131.2	10	0.03	1,250	100	1.43	1.46	11.68	Uniform fine sandy, silty clay
Install 4 Spool Connections to Main Line	DSV	4	4	1	131.2	10	0.03	1,250	100	1.43	1.46	5.84	Uniform fine sandy, silty clay
<b>Pre-commissioning</b>													
Pre -Commission the System	DSV	2	4	2	131.2	10	0.03	1,250	100	1.43	1.46	11.68	Uniform fine sandy, silty clay
<b>TYMS Installation – One TYMS first year. TYMS added as expansion progresses. Fully Developed (x4)</b>													
Installation of TYMS	Derrick Barge	1 (4)	8	1 (4)	180.4	10	0.04	1,250	100	1.43	1.47	11.76 (47.04)	Uniform fine sandy, silty clay
Installation of Tie-in Spool Connections to TYMS	DSV	1 (4)	4	1 (4)	131.2	10	0.03	1,250	100	1.43	1.46	5.84 (23.36)	Uniform fine sandy, silty clay

DSV = Dive Support Vessel

<sup>A</sup> Based on 4 port/starboard forward and aft anchors deployment

<sup>B</sup> Based on 4 port/starboard lateral anchors deployment